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- ☒ Request (6) sheets  
☒ Description (12) sheets  
☒ Abstract (1) sheets  
☒ Claims (4) sheets  
☒ Drawings (4) sheets  
☒ Fee Calculation sheet  
☒ Transmittal Letter  
☒ Certificate of Mailing  
☐ Power of Attorney  
☐ Comments to Abstract  
☒ Other: Return Acknowledgment Postcard

- ☐ Copy of General Power of Attorney  
☐ Sequence Listing Diskette  
☐ Transmittal Letter for Diskette  
☐ Demand ( ) sheets  
☐ Article 19 Amendment ( ) sheets  
☐ Article 34 Amendment ( ) sheets  
☐ Response to Invitation ( ) sheets  
☐ Response to Written Opinion ( ) sheets  
☐ Request for Extension of Time  
☐ Confirmation of Precautionary Designation

Check for \$	<input checked="" type="checkbox"/> Charge Deposit Acct. 501946 \$	\$2,038	Atty Init.	SAB	Txpr. #	6806	Secy. or PL:	jeb
CMS Descrip.: <u>(1) - \$2,038</u>								
THE PATENT AND TRADEMARK OFFICE DATE STAMPED HEREON IS ACKNOWLEDGEMENT THAT THE ITEMS, CHECKED ABOVE, WERE RECEIVED BY THE PTO ON THE DATE STAMPED.								

Applicant: David A. Jackson, et al. Docket No. (066396-0060)  
 Title: DIAGNOSING MALFUNCTIONING WHEEL ALIGNMENT SYSTEM Serial/Reg./Patent No.  
 Date Sent: 7/25/2003 ☐ Hand Carried ☐ Fax ☐ Electronic ☒ Cert. of Mailing ☒ Express Mail No. EV313253205US

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**SNAP-ON TECHNOLOGIES, INC. (all states except US); JACKSON,  
David A., ROBB, Michael J. and O'MAHONY, Patrick B. (US only)**

USPTO OR REFERENCE NUMBER  
**66396-060**

ENTITLED

**DIAGNOSING MALFUNCTIONING WHEEL ALIGNMENT SYSTEM**

Certification under 37 CFR 1.10 (if applicable)

Express Mail Label No.

EV313253205US

Date of Deposit 25-JULY-2003

I hereby certify that application (along with any paper referred to as being attached or enclosed) is being deposited with the United States Postal Service with sufficient postage in an envelope addressed to: Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Jessica S. Brown

(Typed or printed name of person mailing application)

(Signature of person mailing application)

To the International Bureau (RO/US):

Accompanying this transmittal letter is the above-identified International application, including a completed Request form (PCT/RO/101). Please process the application according to the provisions of the Patent Cooperation Treaty.

The following requests are made of the RO/US:

1. ☒ Preparation and Transmittal of Certified Copy of Priority Documents  
☒ Please prepare and transmit to the International Bureau a certified copy of the United States origin priority documents identified in Box VI of the Request form (37 CFR 1.451).  
To cover the cost of copy preparation and certification (37 CFR 1.19(a)(3) and (b)(1)),  
☐ a (check) (money order) in the amount of \$\_\_\_\_\_ is attached to this transmittal letter.  
☒ the RO/US is hereby authorized to charge Deposit Account No. 501946 the fees as calculated on the fee calculation sheet
2. ☒ CHOICE OF INTERNATIONAL SEARCHING AUTHORITY.—It is requested that the International Search be performed by the following International Searching Authority:  
☐ United States Patent and Trademark Office (ISA/US)  
☒ European Patent Office (ISA/EP)

The appropriate Search fee for the above-named Authority is indicated on the Fee Calculation Sheet (PCT/RO/101 Annex).

3. ☐ SUPPLEMENTAL SEARCH FEES (ONLY WHEN ISA/US CONDUCTS THE INTERNATIONAL SEARCH.)—Please charge any Supplemental Search fees that may be required by the United States International Searching Authority (ISA/US) to Deposit Account No. 501946.

*I understand that this authorization is subject to my oral confirmation thereof in each instance and that it in no way limits my right to submit a protest against payment of the Supplemental Search fees, but is merely an administrative and to assure that the ISA/US may timely complete the Search Report.*

NOTE: SUPPLEMENTAL SEARCH FEES FOR ISA/EP ARE PAYABLE DIRECTLY TO THE EUROPEAN PATENT OFFICE.

4. ☒ DISCLOSURE INFORMATION—In order to assist in screening the accompanying International application for purposes of determining whether a license for foreign transmittal should and could be granted and for other purposes, the following information is supplied:

- A. ☒ There is no prior filed application relating to this invention.  
B. ☐ There is a prior application, serial number 60/398,633 filed on 25 July 2002 which contains subject matter that is  
1. ☐ substantially identical to that of the accompanying International application.  
2. ☒ less than that of the accompanying International application.  
3. ☐ more than that of the accompanying International application.  
C. ☐ Disclosure information cannot be covered by the language of Points 4A or 4B above due to involvement of several prior applications or for other reasons. A separate sheet on which the disclosure information is explained is attached to this transmittal letter.
5. ☐ REQUEST FOR FOREIGN TRANSMITTAL LICENSE—According to the provisions of 35 U.S.C. 184 and 37 CFR 5.11, a license to transmit the accompanying International application to foreign agencies or international authorities is hereby requested.

SIGNER IS THE

- ☐ APPLICANT  
☐ COMMON REPRESENTATIVE  
☒ ATTORNEY (AGENT)  
REG. NO. 28,590

NAME OF SIGNER (typed)

BROWN, Marc E. for BECKER, Stephen A.

SIGNATURE

AUTHORIZATION TO CHARGE NEEDED FEES TO DEPOSIT  
ACCOUNT NO. 501946

PTO-102 (REV 3-94)

Department of Commerce USCOMM-DC 94 3817

# PCT

## REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only
International Application No.
International Filing Date
Name of receiving Office and "PCT International Application"
Applicant's or agent's file reference (if desired) (12 characters maximum) 66396-059

Box No. I	TITLE OF INVENTION	
DIAGNOSING MALFUNCTIONING WHEEL ALIGNMENT SYSTEM		
Box No. II	APPLICANT <input type="checkbox"/> This person is also inventor	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)		Telephone No. ---
SNAP-ON TECHNOLOGIES, INC. 420 Barclay Boulevard Lincolnshire, Illinois 60069 United States of America		Facsimile No. ---
		Teleprinter No.
		Applicant's registration No. with the Office
State (that is, country) of nationality: United States of America		State (that is, country) of residence: United States of America
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input checked="" type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box		
Box No. III	FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)		This person is:
JACKSON, David A. 1879 Senter Road San Jose, California 95112 United States of America		<input type="checkbox"/> applicant only <input checked="" type="checkbox"/> applicant and inventor <input type="checkbox"/> inventor only (If this check-box is marked, do not fill in below.)
		Applicant's registration No. with the Office
State (that is, country) of nationality: United States of America		State (that is, country) of residence: United States of America
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input checked="" type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box		
<input checked="" type="checkbox"/> Further applicants and/or (further) inventors are indicated on a continuation sheet.		
Box No. IV	AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE	
The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:		<input checked="" type="checkbox"/> agent <input type="checkbox"/> common representative
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)		Telephone No.
BECKER, Stephen A. McDermott, Will & Emery 600 13th Street, N.W. Washington, D.C. 20005-3096 United States of America		202.756-8000
		Facsimile No.
		202.756-8087
		Teleprinter No.
		Agent's registration No. with the Office
		26,527
<input type="checkbox"/> Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.		

**Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)**

*If none of the following sub-boxes is used, this sheet should not be included in the request.*

Name and address: <i>(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</i> <b>ROBB, Michael J.</b> <b>1879 Senter Road</b> <b>San Jose, California 95112</b> <b>United States of America</b>		This person is: <input type="checkbox"/> applicant only <input checked="" type="checkbox"/> applicant and inventor <input type="checkbox"/> inventor only <i>(If this check-box is marked, do not fill in below.)</i>
State <i>(that is, country)</i> of nationality: <b>United States of America</b>		State <i>(that is, country)</i> of residence: <b>United States of America</b>
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input checked="" type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box		
Name and address: <i>(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</i> <b>O'MAHONY, Patrick B.</b> <b>1879 Senter Road</b> <b>San Jose, California 95112</b> <b>United States of America</b>		This person is: <input type="checkbox"/> applicant only <input checked="" type="checkbox"/> applicant and inventor <input type="checkbox"/> inventor only <i>(If this check-box is marked, do not fill in below.)</i>
State <i>(that is, country)</i> of nationality: <b>Ireland</b>		State <i>(that is, country)</i> of residence: <b>United States of America</b>
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input checked="" type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box		
Name and address: <i>(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</i> (This box is blank)		This person is: <input type="checkbox"/> applicant only <input type="checkbox"/> applicant and inventor <input type="checkbox"/> inventor only <i>(If this check-box is marked, do not fill in below.)</i>
State <i>(that is, country)</i> of nationality: (This box is blank)		State <i>(that is, country)</i> of residence: (This box is blank)
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box		
Name and address: <i>(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</i> (This box is blank)		This person is: <input type="checkbox"/> applicant only <input type="checkbox"/> applicant and inventor <input type="checkbox"/> inventor only <i>(If this check-box is marked, do not fill in below.)</i>
State <i>(that is, country)</i> of nationality: (This box is blank)		State <i>(that is, country)</i> of residence: (This box is blank)
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box		
<input type="checkbox"/> Further applicants and/or (further) inventors are indicated on another continuation sheet.		

## Box No. V DESIGNATION OF STATES

Mark the applicable check-boxes below; at least one must be marked.

The following designations are hereby made under Rule 4.9(a):

## Regional Patent

- ☒ **AP** ARIPO Patent: GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, MZ Mozambique, SD Sudan, SL Sierra Leone, SZ Swaziland, TZ United Republic of Tanzania, UG Uganda, ZM Zambia, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT (if other kind of protection or treatment desired, specify on dotted line) .....
- ☒ **EA** Eurasian Patent: AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT .....
- ☒ **EP** European Patent: AT Austria, BE Belgium, BG Bulgaria, CH & LI Switzerland and Liechtenstein, CY Cyprus, CZ Czech Republic, DE Germany, DK Denmark, EE Estonia, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, SI Slovenia, SK Slovakia, TR Turkey, and any other State which is a Contracting State of the European Patent Convention and of the PCT .....
- ☒ **OA** OAPI Patent: BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, GQ Equatorial Guinea, GW Guinea-Bissau, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT (if other kind of protection or treatment desired, specify on dotted line) .....

## National Patent (if other kind of protection or treatment desired, specify on dotted line):

- |   |  |   |
|---|--|---|
| <input checked="" type="checkbox"/> AE United Arab Emirates               | <input checked="" type="checkbox"/> GM Gambia                                    | <input checked="" type="checkbox"/> NZ New Zealand                      |
| <input checked="" type="checkbox"/> AG Antigua and Barbuda                | <input checked="" type="checkbox"/> HR Croatia                                   | <input checked="" type="checkbox"/> OM Oman                             |
| <input checked="" type="checkbox"/> AL Albania                            | <input checked="" type="checkbox"/> HU Hungary                                   | <input checked="" type="checkbox"/> PH Philippines                      |
| <input checked="" type="checkbox"/> AM Armenia                            | <input checked="" type="checkbox"/> ID Indonesia                                 | <input checked="" type="checkbox"/> PL Poland                           |
| <input checked="" type="checkbox"/> AT Austria                            | <input checked="" type="checkbox"/> IL Israel                                    | <input checked="" type="checkbox"/> PT Portugal                         |
| <input checked="" type="checkbox"/> AU Australia                          | <input checked="" type="checkbox"/> IN India                                     | <input checked="" type="checkbox"/> RO Romania                          |
| <input checked="" type="checkbox"/> AZ Azerbaijan                         | <input checked="" type="checkbox"/> IS Iceland                                   | <input checked="" type="checkbox"/> RU Russian Federation               |
| <input checked="" type="checkbox"/> BA Bosnia and Herzegovina             | <input checked="" type="checkbox"/> JP Japan                                     |   |
| <input checked="" type="checkbox"/> BB Barbados                           | <input checked="" type="checkbox"/> KE Kenya                                     | <input checked="" type="checkbox"/> SC Seychelles                       |
| <input checked="" type="checkbox"/> BG Bulgaria                           | <input checked="" type="checkbox"/> KG Kyrgyzstan                                | <input checked="" type="checkbox"/> SD Sudan                            |
| <input checked="" type="checkbox"/> BR Brazil                             | <input checked="" type="checkbox"/> KP Democratic People's Republic of Korea     | <input checked="" type="checkbox"/> SE Sweden                           |
| <input checked="" type="checkbox"/> BY Belarus                            | <input checked="" type="checkbox"/> KR Republic of Korea                         | <input checked="" type="checkbox"/> SG Singapore                        |
| <input checked="" type="checkbox"/> BZ Belize                             | <input checked="" type="checkbox"/> KZ Kazakhstan                                | <input checked="" type="checkbox"/> SK Slovakia                         |
| <input checked="" type="checkbox"/> CA Canada                             | <input checked="" type="checkbox"/> LC Saint Lucia                               | <input checked="" type="checkbox"/> SL Sierra Leone                     |
| <input checked="" type="checkbox"/> CH & LI Switzerland and Liechtenstein | <input checked="" type="checkbox"/> LK Sri Lanka                                 | <input checked="" type="checkbox"/> TJ Tajikistan                       |
| <input checked="" type="checkbox"/> CN China                              | <input checked="" type="checkbox"/> LR Liberia                                   | <input checked="" type="checkbox"/> TM Turkmenistan                     |
| <input checked="" type="checkbox"/> CO Colombia                           | <input checked="" type="checkbox"/> LS Lesotho                                   | <input checked="" type="checkbox"/> TN Tunisia                          |
| <input checked="" type="checkbox"/> CR Costa Rica                         | <input checked="" type="checkbox"/> LT Lithuania                                 | <input checked="" type="checkbox"/> TR Turkey                           |
| <input checked="" type="checkbox"/> CU Cuba                               | <input checked="" type="checkbox"/> LU Luxembourg                                | <input checked="" type="checkbox"/> TT Trinidad and Tobago              |
| <input checked="" type="checkbox"/> CZ Czech Republic                     | <input checked="" type="checkbox"/> LV Latvia                                    |   |
| <input checked="" type="checkbox"/> DE Germany                            | <input checked="" type="checkbox"/> MA Morocco                                   | <input checked="" type="checkbox"/> TZ United Republic of Tanzania      |
| <input checked="" type="checkbox"/> DK Denmark                            | <input checked="" type="checkbox"/> MD Republic of Moldova                       | <input checked="" type="checkbox"/> UA Ukraine                          |
| <input checked="" type="checkbox"/> DM Dominica                           | <input checked="" type="checkbox"/> MG Madagascar                                | <input checked="" type="checkbox"/> UG Uganda                           |
| <input checked="" type="checkbox"/> DZ Algeria                            | <input checked="" type="checkbox"/> MK The former Yugoslav Republic of Macedonia | <input checked="" type="checkbox"/> US United States of America         |
| <input checked="" type="checkbox"/> EC Ecuador                            | <input checked="" type="checkbox"/> MN Mongolia                                  | <input checked="" type="checkbox"/> UZ Uzbekistan                       |
| <input checked="" type="checkbox"/> EE Estonia                            | <input checked="" type="checkbox"/> MW Malawi                                    | <input checked="" type="checkbox"/> VC Saint Vincent and the Grenadines |
| <input checked="" type="checkbox"/> ES Spain                              | <input checked="" type="checkbox"/> MX Mexico                                    | <input checked="" type="checkbox"/> VN Viet Nam                         |
| <input checked="" type="checkbox"/> FI Finland                            | <input checked="" type="checkbox"/> MZ Mozambique                                | <input checked="" type="checkbox"/> YU Yugoslavia                       |
| <input checked="" type="checkbox"/> GB United Kingdom                     | <input checked="" type="checkbox"/> NO Norway                                    | <input checked="" type="checkbox"/> ZA South Africa                     |
| <input checked="" type="checkbox"/> GD Grenada                            |  | <input checked="" type="checkbox"/> ZM Zambia                           |
| <input checked="" type="checkbox"/> GE Georgia                            |  | <input checked="" type="checkbox"/> ZW Zimbabwe                         |
| <input checked="" type="checkbox"/> GH Ghana                              |  |   |

Check-boxes below reserved for designating States which have become party to the PCT after issuance of this sheet:

- |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

**Precautionary Designation Statement:** In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. (Confirmation (including fees) must reach the receiving Office within the 15-month time limit.)

**Supplemental Box**

*If the Supplemental Box is not used, this sheet should not be included in the request.*

1. *If, in any of the Boxes, except Boxes Nos. VIII(i) to (v) for which a special continuation box is provided, the space is insufficient to furnish all the information: in such case, write "Continuation of Box No. ...." (indicate the number of the Box) and furnish the information in the same manner as required according to the captions of the Box in which the space was insufficient, in particular:*
  - (i) *If more than two persons are to be indicated as applicants and/or inventors and no "continuation sheet" is available; in such case, write "Continuation of Box No. III" and indicate for each additional person the same type of information as required in Box No. III. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below:*
    - Steven W. Allis, Reg. No. 50,532
    - Mark C. Bach, Reg. No. 34,766
    - Stephen A. Becker, Reg. No. 26,527
    - John G. Bisbikis, Reg. No. 37,095
    - Marc E. Brown, Reg. No. 28,590
    - Daniel Bucca, Reg. No. 42,369
    - Daphne L. Burton, Reg. No. 45,323
    - Kenneth L. Caga, Reg. No. 26,151
    - Jennifer Chen, Reg. No. 42,404
    - Bernard P. Codd, Reg. No. 46,429
    - Lawrence T. Cullen, Reg. No. 44,489
    - Paul Devinsky, Reg. No. 28,553
    - Margaret M. Duncan, Reg. No. 30,879
    - Shamita De Etienne-Cummings, Reg. No. 46,072
    - Ramyar M. Farid, Reg. No. 46,469
    - Brian E. Ferguson, Reg. No. 36,801
    - Michael E. Fogarty, Reg. No. 36,139
    - John R. Fuisz, Reg. No. 37,327
    - Craig A. Gelfound, Reg. No. 41,032
    - Keith E. George, Reg. No. 34,111
    - John A. Hankins, Reg. No. 32,029
    - Eric J. Kraus, Reg. No. 36,190
    - Catherine Krupka, Reg. No. 46,227
    - Jack Q. Lever, Reg. No. 28,149
    - Raphael V. Lupo, Reg. No. 28,363
    - Burman Y. Mathia III, Reg. No. 44,907
    - Michael A. Messina, Reg. No. 33,424
    - Michael Oleinik, Reg. No. 41,228
    - Dawn L. Palmer, Reg. No. 41,238
    - Joseph H. Paquin, Jr., Reg. No. 31,647
    - Scott D. Paul, Reg. No. 42,984
    - William D. Pegg, Reg. No. 42,988
    - Robert L. Price, Reg. No. 22,685
    - Charles Rosenberg, Reg. No. 31,464
    - Gene Z. Rubinson, Reg. No. 33,351
    - Joy Ann G. Serauskas, Reg. No. 27,952
    - David A. Spenard, Reg. No. 37,449
    - Arthur J. Steiner, Reg. No. 26,106
    - Wesley Strickland, Reg. No. 44,363
    - Michael D. Switzer, Reg. No. 39,552
    - David M. Tennant, Reg. No. 48,362
    - Judith L. Toffenetti, Reg. No. 39,048
    - Daniel S. Trainor, Reg. No. 43,949
    - Kelli N. Watson, Reg. No. 47,170
    - Cameron K. Weiffenbach, Reg. No. 44,488
    - Aaron Weissstuck, Reg. No. 41,557
    - Edward J. Wise, Reg. No. 34,523
    - Jeffrey A. Woller, Reg. No. 48,041
    - Alexander V. Yampolsky, Reg. No. 36,324
    - Robert W. Zeinick, Reg. No. 36,976
  - (ii) *If, in Box No. II or in any of the sub-boxes of Box No. III, the indication "the States indicated in the Supplemental Box" is checked: in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the applicant(s) involved and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is applicant;*
  - (iii) *If, in Box No. II or in any of the sub-boxes of Box No. III, the inventor or the inventor/applicant is not inventor for the purposes of all designated States or for the purposes of the United States of America: in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the inventor(s) and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is inventor;*
  - (iv) *If, in addition to the agent(s) indicated in Box No. IV, there are further agents: in such case, write "Continuation of Box No. IV" and indicate for each further agent the same type of information as required in Box No. IV;*
  - (v) *If, in Box No. V, the name of any State (or OAPI) is accompanied by the indication "patent of addition," or "certificate of addition," or if, in Box No. V, the name of the United States of America is accompanied by an indication "continuation" or "continuation-in-part": in such case, write "Continuation of Box No. V" and the name of each State involved (or OAPI), and after the name of each such State (or OAPI), the number of the parent title or parent application and the date of grant of the parent title or filing of the parent application;*
  - (vi) *If, in Box No. VI, there are more than five earlier applications whose priority is claimed: in such case, write "Continuation of Box No. VI" and indicate for each additional earlier application the same type of information as required in Box No. VI.*
2. *If, with regard to the precautionary designation statements contained in Box No. V, the applicant wishes to exclude any State(s) from the scope of that statement: in such case, write "Designation(s) excluded from precautionary designation statement" and indicate the name or two-letter code of each State so excluded.*

**Box No. VI PRIORITY CLAIM**

The priority of the following earlier application(s) is hereby claimed:

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is:		
		national application: country or Member of WTO	regional application: regional Office	international application: receiving Office
item (1) 25 July 2002	60/398,633	US		
item (2)				
item (3)				
item (4)				
item (5)				

☐ Further priority claims are indicated in the Supplemental Box.

The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) (only if the earlier application was filed with the Office which for the purposes of this international application is the receiving Office) identified above as:

☒ all items
 ☐ item (1)
 ☐ item (2)
 ☐ item (3)
 ☐ item (4)
 ☐ item (5)
 ☐ other, see Supplemental Box

\* Where the earlier application is an ARIPO application, indicate at least one country party to the Paris Convention for the Protection of Industrial Property or one Member of the World Trade Organization for which that earlier application was filed (Rule 4.10(b)(ii)): . . . .

**Box No. VII INTERNATIONAL SEARCHING AUTHORITY**

Choice of International Searching Authority (ISA) (if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):

ISA / EP

Request to use results of earlier search; reference to that search (if an earlier search has been carried out by or requested from the International Searching Authority):

Date (day/month/year)

Number

Country (or regional Office)

**Box No. VIII DECLARATIONS**

The following declarations are contained in Boxes Nos. VIII (i) to (v) (mark the applicable check-boxes below and indicate in the right column the number of each type of declaration):

Number of  
declarations

- |   |  |   |
|---|--|---|
| <input type="checkbox"/> Box No. VIII (i)   | Declaration as to the identity of the inventor   | : |
| <input type="checkbox"/> Box No. VIII (ii)  | Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent             | : |
| <input type="checkbox"/> Box No. VIII (iii) | Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application | : |
| <input type="checkbox"/> Box No. VIII (iv)  | Declaration of inventorship (only for the purposes of the designation of the United States of America)                               | : |
| <input type="checkbox"/> Box No. VIII (v)   | Declaration as to non-prejudicial disclosures or exceptions to lack of novelty   | : |



**Box No. IX CHECK LIST; LANGUAGE OF FILING**

This international application contains:

(a) In paper form, the following number of sheets:

request (including declaration sheets) : 6  
description (excluding sequence listings and/or tables related thereto) : 12  
claims : 4  
abstract : 1  
drawings : 4

Sub-total number of sheets : 27

sequence listings :  
tables related thereto :

(for both, actual number of sheets if filed in paper form, whether or not also filed in computer readable form; see (c) below)

Total number of sheets : 27

(b) ☐ only in computer readable form (Section 801(a)(i))

(i) ☐ sequence listings  
(ii) ☐ tables related thereto

(c) ☐ also in computer readable form (Section 801(a)(ii))

(i) ☐ sequence listings  
(ii) ☐ tables related thereto

Type and number of carriers (diskette, CD-ROM, CD-R or other) on which are contained the

☐ sequence listings :  
☐ tables related thereto :

(additional copies to be indicated under items 9(ii) and/or 10(ii), in right column)

This international application is accompanied by the following item(s) (mark the applicable check-boxes below and indicate in right column the number of each item):

1. ☒ fee calculation sheet
2. ☐ original separate power of attorney
3. ☐ original general power of attorney
4. ☐ copy of general power of attorney; reference number, if any: .....
5. ☐ statement explaining lack of signature
6. ☐ priority document(s) identified in Box No. VI as item(s): .....
7. ☐ translation of international application into (language): .....
8. ☐ separate indications concerning deposited microorganism or other biological material
9. ☐ sequence listings in computer readable form (indicate type and number of carriers)
  - (i) ☐ copy submitted for the purposes of international search under Rule 13ter only (and not as part of the international application)
  - (ii) ☐ (only where check-box (b)(i) or (c)(i) is marked in left column) additional copies including, where applicable, the copy for the purposes of international search under Rule 13ter
  - (iii) ☐ together with relevant statement as to the identity of the copy or copies with the sequence listings mentioned in left column
10. ☐ tables in computer readable form related to sequence listings (indicate type and number of carriers)
  - (i) ☐ copy submitted for the purposes of international search under Section 802(b-quater) only (and not as part of the international application)
  - (ii) ☐ (only where check-box (b)(ii) or (c)(ii) is marked in left column) additional copies including, where applicable, the copy for the purposes of international search under Section 802(b-quater)
  - (iii) ☐ together with relevant statement as to the identity of the copy or copies with the tables mentioned in left column
11. ☒ other (specify): Filing receipt for priority document; postcard

Number of items

2

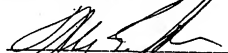
Figure of the drawings which should accompany the abstract: 4

Language of filing of the international application:

English

**Box No. X SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE**

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

  
Marc E. Brown, Reg. No. 28,590  
on behalf of Stephen A. Becker, Reg. No. 26,527

For receiving Office use only

1. Date of actual receipt of the purported international application:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:
4. Date of timely receipt of the required corrections under PCT Article 11(2):
5. International Searching Authority (if two or more are competent): ISA /

2. Drawings:

☐ received

☐ not received

6. ☐ Transmittal of search copy delayed until search fee is paid

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# PCT

## FEE CALCULATION SHEET Annex to the Request

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International Application No.

Date stamp of the receiving Office

Applicant's or agent's  
file reference

66396-059

Applicant

**Snap-on Technologies, Inc. (all states except US); JACKSON, David A.,  
ROBB, Michael J. and O'MAHONY, Patrick B. (Applicant for US only)**

### CALCULATION OF PRESCRIBED FEES

1. TRANSMITTAL FEE

240 T

2. SEARCH FEE

936 S

International search to be carried out by

EP

(If two or more International Searching Authorities are competent to carry out the international search, indicate the name of the Authority which is chosen to carry out the international search.)

3. INTERNATIONAL FEE

Basic Fee

Where items (b) and/or (c) of Box No. IX apply, enter Sub-total number of sheets } 27  
Where items (b) and (c) of Box No. IX do not apply, enter Total number of sheets

b1 first 30 sheets 407 b1

b2 0 x \$9 = 0 b2  
number of sheets fee per sheet  
in excess of 30

b3 additional component (only if sequence listings and/or tables related thereto are filed in computer readable form under Section 801(a)(i), or both in that form and on paper, under Section 801(a)(ii):

400 x = b3  
fee per sheet

Add amounts entered at b1, b2 and b3 and enter total at B 407 B

Designation Fees

The international application contains ALL designations.

5 x \$88 = 440 D  
number of designation fees amount of designation fee payable (maximum 5)

Add amounts entered at B and D and enter total at I 847 I

(Applicants from certain States are entitled to a reduction of 75% of the international fee. Where the applicant is (or all applicants are) so entitled, the total to be entered at I is 25% of the sum of the amounts entered at B and D.)

4. FEE FOR PRIORITY DOCUMENT (if applicable) 15 P

5. TOTAL FEES PAYABLE

\$2,038

Add amounts entered at T, S, I and P, and enter total in the TOTAL box

TOTAL

☐ The designation fees are not paid at this time.

### MODE OF PAYMENT

☒ authorization to charge  
deposit account (see below)

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☐ other (specify):

AUTHORIZATION TO CHARGE (OR CREDIT) DEPOSIT ACCOUNT  
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☒ Authorization to charge the total fees indicated above.

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Receiving Office: RO/ US

Deposit Account No.: 501946

Date: 25 July 2003

Name: Marc E. Brown for Stephen A. Becker

Signature:

# DIAGNOSING MALFUNCTIONING WHEEL ALIGNMENT SYSTEM

## BACKGROUND

**[0001]** *Field of Disclosure*

**[0002]** This application relates to equipment diagnostics and, in one embodiment, technology that facilitates diagnoses of malfunctioning automotive alignment systems.

**[0003]** *General Background and State of the Art*

**[0004]** Automotive diagnostic and repair equipment sometimes fails to function during use or, because of improper use, fails to successfully accomplish its desired function. In particular, equipment used for automotive wheel alignment may be susceptible to malfunctions during use that may be difficult to detect or correct at a later time. This is due to the sensitivity of such equipment to environmental disturbances, as well as to the large number of cooperative components involved in wheel alignment systems.

**[0005]** One example of this problem is during wheel alignment. Wheel alignment is a process of adjusting the angles of wheels on a vehicle so that they are generally perpendicular to the ground and parallel to one another. The purpose of these adjustments is to attain maximum tire life, as well as to keep the vehicle tracks straight when driving along a straight and level road. In order to adjust the wheel angles to achieve proper wheel alignment, the actual wheel angles must first be measured. Then, the requisite adjustments may then be calculated. Two particular angles that are often utilized in wheel alignment methods are commonly referred to as "camber" and "toe." Camber, which is typically measured in degrees, is the angle of the wheel's deviation from a vertical plane. Therefore, camber is angle of the wheel that is seen when viewed from the front of the vehicle. If the top of the wheel is leaning away from the center of the car, the camber is positive; if it is leaning in toward to center of the car, then the camber is negative.

**[0006]** Toe is the difference in distance between the front of two tires and the back of those tires. It is normally measured in fractions of an inch, and is usually

set close to zero, meaning that the wheels are substantially parallel to one another. "Toe-in" means that the fronts of the tires are closer to each other than the rears; "toe-out" is the opposite situation. These, as well as other wheel alignment parameters, are quantified through sensitive measurement techniques that can encounter significant errors in the event of an equipment malfunction or environmental disturbance. Some types of systems for measuring such wheel alignment parameters may be more sensitive than others, though almost all are susceptible to such malfunctions and disturbances.

**[0007]** Wheel alignment may involve placing instrumentation on each of a vehicle's four wheels. The instrumentation may include a set of optical targets clamped to each wheel. An optical sensor means such as a camera is situated to view the targets, and a light may be directed toward the targets with sufficient intensity to cause the targets' reflections to be detected by the optical sensor means. The optical sensor means may view a target located on each wheel and forms an image of each target. Electrical signals corresponding to each of the images may be transferred to a processor, which correlates the perspective image of each of the targets with the true shape of each target. The processor may then relate the known geometric dimensions of the target with the dimensions of corresponding elements in the perspective images, and can thereby calculate the alignment of the wheels. Such methods are well known in the art, and described in detail in U.S. Patents 5,535,522 and 5,809,658, for example, each of which is incorporated herein by reference.

**[0008]** Unfortunately, such procedures and systems can encounter a variety of operational problems due to the sensitivity of the various system components and the sheer number of components that must cooperate during operation of the system. Unfortunately, in the case of malfunctions during use of such equipment, the operator often lacks the skills necessary for diagnosing the malfunction or correcting it. Technicians who service the equipment, on the other hand, might have the ability to diagnose and correct such problems, but are often unable to successfully trouble-shoot operational problems because they are unable to be present during the malfunction. By the time a service technician arrives on the premises, the problem may no longer be observable.

This sometimes leads to the problem not being solved and, in some instances, to the costly replacement of components erroneously thought to have been malfunctioning.

[0009] Therefore, what is needed is an operational malfunction diagnostic method that allows for a skilled technician to diagnose an operational problem even after the problem has occurred and is no longer apparent.

#### **SUMMARY**

[0010] The systems and methods of this application help to overcome these as well as other problems in the prior art by recording data indicative of the circumstances at the time of an apparent problem in a memory device, and then displaying those data to an equipment service technician when he later arrives to service the equipment. As used herein, the term "malfunction event" shall refer to an equipment malfunction or apparent malfunction due to environmental disturbances, which will be discussed in further detail below.

[0011] In one aspect of the application, a diagnostic system for troubleshooting a malfunction during operation of an instrument that gathers and analyzes real-time data may include one or more information-gathering devices for gathering the real-time data, a memory device in communication therewith for storing the real-time data, and a data replay system in communication with the memory device for playing back the real-time data after the real time data was gathered.

[0012] In another aspect of the application, a diagnostic system for allowing a service technician to diagnose a malfunction during operation of a wheel alignment system that gathers information in real time about the alignment of a plurality of wheels may include one or more cameras for gathering images of the alignment in real time. The images may include reflections from a target mounted on each wheel, and a processing system in communication with the cameras may receive the images and generate analysis data based on them, the analysis data providing an analysis of the alignment of the wheels. A memory device may store the images and the analysis data, and a storage control may cause the memory device to store the images and the analysis data in response to activation of the storage control by the operator during the occurrence of the

malfunction. Alternatively, activation of the storage control may occur automatically as part of a rolling data collection history or following an automatic detection of a pre-defined trigger. A display device in communication with the memory device may selectively display the images and the analysis data, and a play-back control may cause the display device to selectively display the images, analysis data and other captured data whether processed or unprocessed, to the service technician in response to activation of the play-back control after the occurrence of the malfunction. Data that are played back may include, but are not limited to, captured alignment data, processed data, intermediate alignment results, final alignment values, processed images, and the like. The data may be played back sequentially in order to mimic its original real-time capture, or may be played back selectively according to a user's input. Also, data collection may occur on a rolling basis, such that data is continually collected and buffered in memory, then erased as new data is collected, becoming permanently stored only when the system enters a diagnostic mode, whether by user control or automatic detection. The rolling data collection ensures that any data collected for a malfunction event is preceded by a certain amount of buffered data that was collected immediately prior to the malfunction event.

**[0013]** In yet another aspect of the application, a method of diagnosing a malfunction during the operation of an instrument that gathers and analyzes real-time wheel alignment data may include receiving real-time wheel alignment data from at least one information-gathering device, storing the data in a memory device, re-playing the stored data, and analyzing the re-played data to diagnose a malfunction. Real-time wheel alignment data may also be calculated from stored analysis data, then re-played and analyzed to diagnose a malfunction.

**[0014]** In a further aspect of the application, a means for diagnosing a malfunction during the operation of an instrument that gathers and analyzes real-time wheel alignment data may include receiving means for receiving real-time wheel alignment data from at least one information-gathering means, storage means for storing the data, playback means for re-playing the stored data, and processor means for analyzing the re-played data to diagnose a malfunction.

**[0015]** The foregoing and other objects, features, and advantages of the disclosures herein will become apparent from a reading of the following detailed description of exemplary embodiments thereof, in conjunction with the accompanying drawings.

**[0016]** It is understood that other embodiments of the disclosures herein will become readily apparent to those skilled in the art from the following detailed description, wherein it is shown and described only exemplary embodiments of those disclosures by way of illustration. As will be realized, the disclosures herein are capable of being implemented and practiced in other and different embodiments and its several details are capable of modification in various other respects, all without departing from the spirit and scope of their teachings. Accordingly, the drawings and detailed description are to be regarded as illustrative in nature and not as restrictive.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

**[0017]** FIG. 1 illustrates an exemplary wheel alignment system;

**[0018]** FIG. 2 illustrates a method for diagnosing a malfunction that occurs during the operation of an information gathering device after the malfunction occurs;

**[0019]** FIG. 3A is a block diagram illustrating components of an equipment operational malfunction diagnostic system;

**[0020]** FIG. 3B is a block diagram illustrating an alternative embodiment of one portion of the operational malfunction diagnostic system of FIG. 3A;

**[0021]** FIG. 4 is a block diagram illustrating additional components of an exemplary equipment operational malfunction diagnostic system; and

**[0022]** FIG. 5 is a table of exemplary data gathered and utilized in an equipment operational malfunction diagnostic system.

#### **DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS**

**[0023]** The detailed description set forth below in connection with the appended drawings is intended as a description of exemplary embodiments and is not intended to represent the only embodiments in which the concepts explained in

these embodiments can be practiced. The term "exemplary" means "serving as an example, instance, or illustration," and should not necessarily be construed as preferred or advantageous over other embodiments. The detailed description includes details for the purpose of providing an understanding of the concepts herein. However, it will be apparent to those skilled in the art that these teachings may be implemented and practiced without these specific details.

**[0024]** FIG. 1 illustrates an exemplary wheel alignment system that may be utilized with the diagnostic systems and methods disclosed herein. Information gathering devices may be used to obtain wheel alignment data for each of the wheels 100, 102, 104, and 106 of a vehicle. The information gathering devices may include an optical sensor such as one or more video or other cameras 108 and 110. Cameras 108 and 110 may be focused on individual sets of optical targets, 112, 114, 116, and 118 that are each mounted to one of the wheels 100, 102, 104, and 106. Each set of targets, such as set 112, may include a plurality of optical targets 120. A light or pair of lights 122 and 124, such as a strobe or other type of light, may project light onto targets 120 to cause them to reflect light sufficient to be detected by cameras 108 and 110.

**[0025]** Cameras 108, 110 view each target 120 located on each of the wheels 100, 102, 104, 106 and forms an image of each target. Electrical signals corresponding to each of the images are transferred to a processor, which correlates the perspective image of each of the targets with the true shape of each target. The processor relates the known geometric dimensions of the target with the dimensions of corresponding elements in the perspective images. This process is repeated for each of a plurality of different vehicle positions, such that wheel alignment parameters can be calculated from the collected data. Such systems methods are well known in the art, and are described for example in the patents referenced above, U.S. Patents 5,535,522 and 5,809,658. Unfortunately, a variety of malfunction events are possible with these types of optical alignment systems. Hardware failures may occur, some being permanent and others being intermittent. Also, environmental disturbances can interfere with a camera's or optical target's normal operation, causing the appearance of hardware failure.



**[0026]** Environmental disturbances that the systems and methods disclosed herein can diagnose include, but are not necessarily limited to, an object or person that blocks the line of sight between a camera and an optical target that is mounted on a wheel, dirt or debris that is on one of the optical targets, causing it to be undetectable to the camera, or sunlight and other reflections in the area of the alignment operation. For example, a vehicle's own chrome details can cause reflections that interfere with a camera's detection of the mounted optical targets. Other environmental issues include the vehicle not being within the camera's focal length, vibrations that occur during the alignment process, or large temperature gradients that cause what is known in the art as a "mirage effect."

**[0027]** Hardware faults that the systems and methods disclosed herein can diagnose include, but are not necessarily limited to, intermittent camera failures, or optical target alignment problems. For example, problems with the cameras or the targets may cause one or more targets to become invisible to a camera during a certain portion of the alignment process, such as when the vehicle is in a rolled-back position, yet be visible during other portions of the process, such as when the vehicle is in its normal, starting position. Both environmental and hardware issues may be difficult to detect after the actual occurrence, particularly if they are intermittent in nature. Therefore, the systems and methods disclosed herein may involve capturing alignment data during the alignment process, storing the data during a malfunction event, then allowing an experienced technician to "recreate" the malfunction event by reviewing and analyzing the collected and stored data.

**[0028]** FIG. 2 illustrates a method for diagnosing a malfunction that occurs during the operation of an information gathering device after the malfunction occurs. Alignment data are received by instrumentation in a wheel alignment system, such as cameras operating in conjunction with optical targets, for example. The data collection occurs during a malfunction event, and is triggered by an alignment technician upon noticing a malfunction in the alignment process. When a malfunction is detected, the alignment system may be placed in a diagnostic mode, which causes the real-time data to be collected at regular, pre-

determined intervals, indicated at block 200. For example, the data may be collected once every two seconds for the first 10 seconds, once every four seconds during the following 8 seconds, and once every five seconds thereafter. Of course, the disclosures herein are applicable to any data collection frequency, and the frequency need not diminish over time. The frequency may be variable according to a variety of different patterns or triggers, such as pre-defined programmable triggers based upon out-of-tolerance conditions, deteriorating or improving conditions, and the like. Also, the alignment system may always collect real-time data, keeping a certain amount of it in memory while discarding older data, so that some amount of real-time data is constantly scrolled through the system's memory. That way, when a malfunction event does occur and the system switches to diagnostic mode, it will have some amount of historical data to supplement the real-time data it gathers in the diagnostic mode. It is also possible to pre-define various triggers for initiating the diagnostic mode data collection and storage, such as triggers based upon data levels indicative of certain conditions, and to begin capturing the data after a trigger is detected. The triggers can include an out of tolerance condition or a deteriorating condition.

**[0029]** At block 202, the data received during the diagnostic mode are stored, such as in temporary or permanent computer storage. At a later time, the data are recalled from memory, and is re-played as indicated at block 204. It is at this time that an experienced alignment system technician can re-play the previously collected data to "recreate" the malfunction event and analyze the re-played data to diagnose the malfunction. A description of the format and content of the re-played data is discussed in further detail below with reference to FIG. 5. During the data re-play, the diagnostic technician can analyze the data, as indicated at block 206, to troubleshoot for system malfunctions or environmental interferences, which can then be selectively corrected and remedied.

**[0030]** FIG. 3A is a block diagram illustrating components of an equipment operational malfunction diagnostic system. Information gathering devices 300, 302, such as cameras focused on optical targets for example, collect alignment data for the wheels on which the optical targets are mounted. As described

above, the collection may be triggered during the occurrence of an alignment system malfunction. An alignment system operator, upon detecting an malfunction, or an apparent malfunction due to environmental issues, enables the diagnostic system. This may be done by placing the alignment system into a diagnostic mode, or a separate diagnostic system may be utilized to collect alignment data during a malfunction event. In either case, the system is triggered to collect alignment data at each of a series of time intervals, as described above.

**[0031]** The information collected during the malfunction event is stored in memory 304, which may be permanent or temporary computer memory. Then, a data replay system 306 presents the recalled data to a diagnostic technician, who is able to review the malfunction event and diagnose it by analyzing the real-time data that had been collected during the event. In this manner, the diagnostic technician is able to "recreate" the malfunction event. For example, in a scenario in which a plurality of "snapshot" images was taken of targets mounted on wheels during a malfunction, that series of images can be re-played to a diagnostic technician well after the event has occurred. Thus, while the malfunction or apparent malfunction may have been intermittent, and may no longer be apparent, it can still be examined and diagnosed by an experienced technician who was not present when the event occurred. The data replay system may include a computer and a display screen for retrieving the stored data, analyzing them such as by processing images, and displaying the data to the diagnostic technician.

**[0032]** FIG. 3B is a block diagram illustrating an alternative embodiment of one portion of the operational malfunction diagnostic system of Fig. 3A, in which alignment data stored in memory 304 is transmitted to a diagnostic technician for review on data replay system 306 over a communications network 308. Communications network may comprise the Internet, a local area network, a wireless network, or any other form of data transfer platform. In this embodiment, the diagnostic technician can remotely troubleshoot a malfunctioning alignment system by receiving malfunction episode alignment

data across network 308 at any location that has a data replay system 306 available for use.

**[0033]** FIG. 4 is a block diagram illustrating additional components of an exemplary equipment operational malfunction diagnostic system. A camera 400 collects data from optical targets mounted on wheels that are undergoing a malfunctioning alignment process. An image processor 402 receives the data and processes the resultant images. These images are utilized to calculate the wheels' alignment angles by alignment processor 404, and stored in a memory device 406. A storage controller 408, which may be hardware or software driven, causes the images to be stored at each of a sequence of pre-determined time intervals. The frequency of these time intervals may be variable according to a variety of different patterns or triggers. For example, data may be collected at a rate that is based upon the severity of the malfunction event, such as by programming pre-defined triggers based upon out-of-tolerance conditions, deteriorating or improving conditions, and the like.

**[0034]** During a diagnostic phase, during which a diagnostic technician can review and analyze the collected data, the images are presented on a display device 410. This may comprise a display monitor for presenting images and other forms of the collected data, as illustrated in FIG. 5. A playback controller 412, which may be hardware or software driven, is operated by the diagnostic technician to manipulate the playback sequence on display device 410. The diagnostic technician can thereby choose to "recreate" the malfunction event exactly, or to focus on certain moments during the malfunction event. Data that are played back to investigate the malfunction event may include, but are not limited to, captured alignment data, processed data, intermediate alignment results, final alignment values, processed images, and the like.

**[0035]** FIG. 5 illustrates exemplary data gathered and utilized in an exemplary malfunction diagnostic system. The display device and display system referenced in previous figures may present data in numeric or other formats in addition to the images previously described. For example, certain types of data collected during a malfunction event may be expressed in table format, as illustrated by exemplary table 500. The exemplary table 500 includes a first

column denoting time intervals  $T_0$  502 through  $T_N$  504, at which diagnostic alignment data were collected and stored by an alignment system operating in its diagnostic mode. For each of these time intervals, the table reports values such as intensity 506, camera gain or amplification 508, and an error value based on a root mean squared operation (RMS) 510. Intensity relates to the level of reflection produced by an optical target, and to the ability of a camera to detect it. Gain relates to the amplification of the camera, and therefore also relates to the ability of a camera to detect a reflective optical target. RMS relates to a well-known error analysis algorithm that can be applied to data that are collected by an alignment system. It is seen that the intensity of one optical target at the first and last time intervals is 140, while the intensity of that same optical target at the second two time interval is 0. Thus, a malfunction can be identified as having occurred between those two time intervals. Similarly, the RMS values reveal a malfunction. Based on these and other values, the specific cause of the malfunction can be analyzed and targeted by an experienced and skilled diagnostic technician. Of course, it is to be understood that other values may be measured, expressed and analyzed according to the disclosures herein, which are not limited to the specific illustrative examples discussed. For example, wheel alignment systems and malfunction diagnostic systems may record and report distances to test whether an optical target is within a camera's focal length; relative angular positions of an optical target in three dimensional space, the number of targets that are visible to a camera, the number of targets used in an alignment calculation, a variety of camera parameters, and the like.

[0036] The various figures and diagrams described in connection with the embodiments disclosed herein may be implemented or performed with hardware components, software components or any combination thereof designed to perform the functions described herein. The previous description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the teachings of the present disclosure. Various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the spirit or scope of the application. Thus, the disclosures herein are not intended to be limited to the embodiments shown and discussed, but are

to be accorded the widest scope consistent with the principles and novel features disclosed herein.

**WE CLAIM:**

1. A diagnostic system for diagnosing a malfunction during the operation of an instrument that gathers and analyzes real-time data comprising:
  - one or more information-gathering devices for gathering the real-time data;
  - a memory device in communication with the information-gathering devices for storing the real-time data; and
  - a data replay system in communication with the memory device for playing back the real-time data after the real time data was gathered.
2. The diagnostic system of claim 1, wherein the one or more information-gathering devices includes a camera focused on an optical target in a wheel alignment system.
3. The diagnostic system of claim 2 wherein the real-time data comprises a plurality of images gathered from the camera.
4. The diagnostic system of claim 1, further comprising:
  - a data controller in communication with the information-gathering devices and the memory device that causes the memory device to store data from the information-gathering devices at pre-determined time intervals.
5. The diagnostic system of claim 3, wherein the pre-determined time intervals vary in frequency over time.
6. A diagnostic system for allowing a service technician to diagnose a malfunction during operation by an operator of a wheel alignment system that gathers information in real time about the alignment of a plurality of wheels comprising:
  - one or more cameras for gathering images of the alignment in real time, the images including reflections from a target mounted on each wheel;

a processing system in communication with the cameras for receiving the images and for generating analysis data based on the images, the analysis data providing an analysis of the alignment of the wheels;

a memory device for storing the images and the analysis data;

a storage control for causing the memory device to store the images and the analysis data in response to activation of the storage control by the operator during the occurrence of the malfunction;

a display device in communication with the memory device for selectively displaying the images and the analysis data; and

a play-back control for causing the display device to selectively display the images and the analysis data to the service technician in response to activation of the play-back control after the occurrence of the malfunction.

7. The diagnostic system of claim 6 wherein the storage control causes the storage of the images and the analysis data to be accomplished at pre-determined intervals.

8. The diagnostic system of claim 7 wherein the pre-determined intervals vary in frequency over time.

9. A method of diagnosing a malfunction during the operation of an instrument that gathers and analyzes real-time wheel alignment data comprising:

receiving real-time wheel alignment data from at least one information-gathering device;

storing the real-time wheel alignment data in a memory device;

re-playing the stored, real-time wheel alignment data; and

analyzing the re-played data to diagnose a malfunction.

10. The method of claim 9 wherein the at least one information gathering device includes a video camera.



11. The method of claim 10 wherein the real-time wheel alignment data comprises images including reflections from a target mounted on each wheel.
12. The method of claim 11, further comprising:
  - processing the real-time wheel alignment data to generate wheel alignment analysis data;
  - storing the wheel alignment analysis data;
  - re-playing the wheel alignment analysis data in conjunction with the re-playing of the real-time wheel alignment data; and
  - analyzing the re-played wheel alignment analysis data to diagnose a malfunction.
13. The method of claim 9 further comprising transmitting the stored, real-time wheel alignment data across a communications network prior to re-playing it.
14. The method of claim 9 wherein the storing of real-time wheel alignment data in a memory device is done at pre-determined intervals that vary in frequency over time.
15. A means for diagnosing a malfunction during the operation of an instrument that gathers and analyzes real-time wheel alignment data comprising:
  - receiving means for receiving real-time wheel alignment data from at least one information-gathering means;
  - storage means for storing the real-time wheel alignment data;
  - playback means for re-playing the stored, real-time wheel alignment data; and
  - processor means for analyzing the re-played data to diagnose a malfunction.
16. The diagnostic means of claim 9 wherein the at least one means for gathering information gathering includes an imaging means.

17. The diagnostic means of claim 10 wherein the real-time wheel alignment data comprises images including reflections from an optical target mounted on each wheel.

18. The diagnostic means of claim 11 wherein the processor means is a first processor means, the diagnostic means further comprising:

a second processor means for processing the real-time wheel alignment data to generate wheel alignment analysis data;

storage means for storing the wheel alignment analysis data;

the playback means further configured for re-playing the wheel alignment analysis data in conjunction with the re-playing of the real-time wheel alignment data; and

the first processor means further configured for analyzing the re-played wheel alignment analysis data to diagnose a malfunction.

19. The diagnostic means of claim 9 further comprising a transmitting means for transmitting the stored, real-time wheel alignment data across a communications network prior to re-playing it.

20. The diagnostic means of claim 9 wherein the storage means includes a controller means for causing the storing of wheel alignment data to be performed at pre-determined intervals that vary in frequency over time.

## **DIAGNOSING MALFUNCTIONING WHEEL ALIGNMENT SYSTEM**

### **ABSTRACT**

A diagnostic system allows a service technician to diagnose a malfunction that occurs during operation of a wheel alignment system after the malfunction has occurred and is no longer apparent. The system, which includes one or more cameras for gathering images of the alignment, gathers information in real time about the alignment of a plurality of wheels. The images include reflections from a target mounted on each wheel, and a processing system in communication with the cameras receives the images and generates analysis data based on them, the analysis data providing an analysis of the alignment of the wheels. A memory device stores the images and the analysis data, and a storage control causes the memory device to store the images and the analysis data in response to activation of the storage control by the operator during the occurrence of the malfunction. A display device in communication with the memory device selectively displays the images and the analysis data, and a play-back control causes the display device to selectively display the images and the analysis data to the service technician in response to activation of the play-back control after the occurrence of the malfunction.

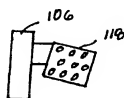
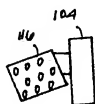
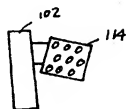
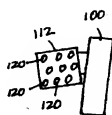


FIG. 1

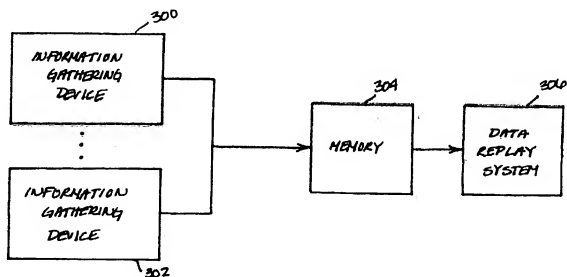


FIG. 3A

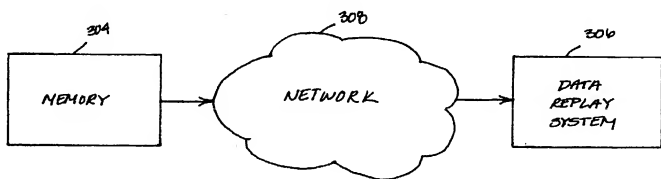


FIG. 3B

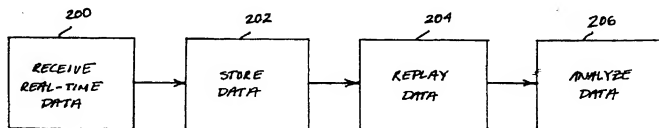


FIG. 2

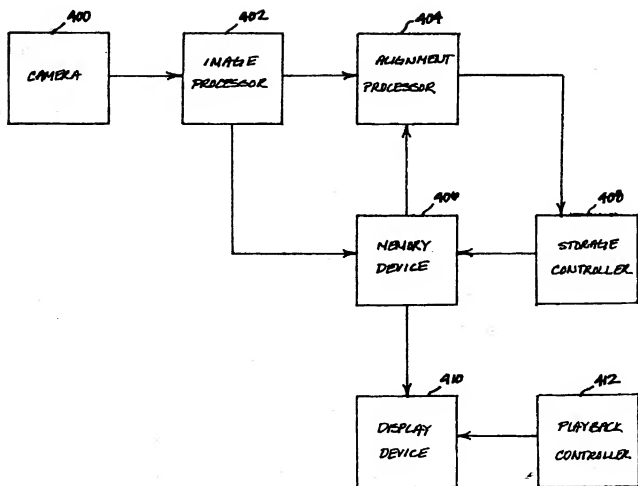


FIG. 4

500

506      508      510

	Intensity	Gain	RMS
502 — $T_0$	140	10	.05
$T_1$	0	10	0
$T_2$	0	10	0
•	•	•	•
•	•	•	•
•	•	•	•
504 — $T_N$	140	10	.05

FIG. 5



## UNITED STATES PATENT AND TRADEMARK OFFICE

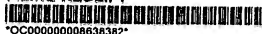
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APPLICATION NUMBER	FILING DATE	GRP ART UNIT	FIL FEE REC'D	ATTY DOCKET NO	DRAWINGS	TOT CLAIMS	IND CLAIMS
60/398,633	07/25/2002		160	010473-0872	5		

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CONFIRMATION NO. 6952

## FILING RECEIPT



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If Required, Foreign Filing License Granted 08/15/2002

Projected Publication Date: Not Applicable

Non-Publication Request: No

Early Publication Request: No

## Title

Wheel alignment diagnostic system and method

## LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 &amp; 5.15



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EV313253219U

July 25, 2003

I hereby certify that this correspondence and identified enclosures are being deposited on July 25, 2003, with the U.S. Postal Service. "Express Mail Post Office to Address" service. No. EV313253219US, under 37 C.F.R. § 1.10, addressed to the Commissioner for Patents, Mail Stop PATENT APPLICATION, P.O. Box 1450, Alexandria, VA 22313-1450.

*Jessica S. Brown*  
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Commissioner for Patents  
Mail Stop PATENT APPLICATION  
P.O. Box 1450  
Alexandria, VA 22313-1450

Re: Client: Snap-on Technologies, Inc.  
Matter No. 66396-059  
U.S. Patent Application  
Title: DIAGNOSING MALFUNCTIONING WHEEL ALIGNMENT SYSTEM  
Inventors: David A. Jackson; Michael J. Robb; Patrick B. O'Mahony

Subject: Transmitting Patent Application for Filing

Dear Sir or Madam:

We enclose for filing the patent application of:

Inventors: David A. Jackson; Michael J. Robb; Patrick B. O'Mahony

For: DIAGNOSING MALFUNCTIONING WHEEL ALIGNMENT SYSTEM

The application includes:

- ☒ Cover page + 17 pages of specification, claims, abstract.
- ☒ Declaration and Power of Attorney signed by the inventors
- ☒ Priority Claim to provisional application serial no. 60/398,633, filed July 25, 2002
- ☒ Four (4) sheets of informal drawings.
- ☒ An Assignment of the invention to Snap-on Technologies, Inc., the recordation cover sheet and assignment recordation fee.

New Patent App ☒ Utility ☐ Design ☐ Cont. ☐ CIP ☐ Div. ☐ PCT ☐ RCE ☐ Prov

☒ Other: Cover

12 pages of Specification  
4 pages of Claims  
1 pages of Abstract  
4 pages of Formal/Informal Drawings

☐ Small Entity ☒ Large Entity

☒ Declaration/Power of Attorney

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Applicant: JACKSON, DAVID, et al. Docket No. 066396-0059

Title: DIAGNOSING MALFUNCTIONING WHEEL ALIGNMENT SYSTEM Serial/Reg./Patent No.                     

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